CLAIMS

1. An SMES device comprising a coil (1) for connection in series with a voltage source (2), e.g. a dc voltage source, and wound from a superconducting cable (12) having superconducting means (14) which, in use, is maintained at cryogenic temperatures below its critical temperature (T_c) and which is surrounded by electrical insulation (20-22), and switch means (3) for short-circuiting the coil (1), characterised in that the said electrical insulation comprises an inner layer (20) of semiconducting material electrically connected to said superconducting means, an outer layer (21) of semiconducting material at a controlled electric potential along its length and an intermediate layer (22) of solid electrically insulating material positioned between said inner and outer layers (20 and 21).

2. An SMES device according to claim 1, characterised in that the device further comprises a cryostat (6) in which the coil (1) and switch means (3) are enclosed.

3. An SMES device according to claim 1 or 2, characterised in that said superconducting means comprises high-temperature superconducting (HTS) means.

4. An SMES device according to claim 3, characterised in that said high-temperature superconducting (HTS) means comprises at least one layer (14) of high-temperature superconducting (HTS) material, cooling means (13) for cryogenically cooling the layer(s) (14) of HTS material below the critical temperature (T_c) of the HTS material and thermally insultating means (15) surrounding the layer(s) (14) of HTS material and the cooling means (13).

5. An SMES device according to claim 4, characterised in that the cooling means (13) comprises a

support tube (13) through which cryogenic cooling fluid is passed and in that the at least one layer (14) of HTS material comprises HTS tape or conductors wound in a helical layer on said support tube (13).

6. An SMES device according to claim 4 or 5, characterised in that the thermally insulating means (15) comprises an annular space under vacuum and containing thermal insulation (18).

7. An SMES device according to any one of the preceding claims, characterised in that the semiconducting outer layer (21) has a resistivity of from 1 to 1000 ohm·cm.

8. An SMES device according to claim 6, characterised in that the said outer layer (21) has a resistivity of from 10 to 500 ohm·cm, preferably from 10 to 100 ohm·cm.

9. An SMES device according to any one of the preceding claims, characterised in that the resistance per axial unit length of the semiconducting outer layer (21) is from 5 to 50,000 ohm.m^{-1}.

10. An SMES device according to any one of claims 1 to 8, characterised in that the resistance per axial unit of length of the semiconducting outer layer (21) is from 500 to 25,000 ohm.m^{-1}, preferably from 2,500 to 5,000 ohm.m^{-1}.

11. An SMES device according to any one of the preceding claims, characterised in that the semiconducting outer layer (21) is contacted by conductor means at said controlled electric potential at spaced apart regions along its length, adjacent contact regions being sufficiently close together that the voltages of mid-points between adjacent contact regions are insufficient for corona discharges to occur within the electrically insulating means.

12. An SMES device according to any one of the preceding claims, characterised in that said controlled electric potential is at or close to earth potential.

13. An SMES device according to any one of the preceding claims, characterised in that the said intermediate layer (22) is in close mechanical contact with each of said inner and outer layers (20 and 21).

14. An SMES device according to any one of claims 1 to 12, characterised in that the said intermediate layer (22) is joined to each of said inner and outer layers (20 and 21).

15. An SMES device according to any one of the preceding claims, characterised in that the strength of the adhesion between the said intermediate layer (22) and each of the semiconducting inner and outer layers (20, 21) is of the same order of magnitude as the intrinsic strength of the material of the intermediate layer.

16. An SMES device according to claim 14 or 15, characterised in that the said layers (20-22) are joined together by extrusion.

17. An SMES device according to claim 16, characterised in that the inner and outer layers (20, 21) of semiconducting material and the insulating intermediate layer (22) are applied together over the superconducting means through a multi layer extrusion die.

18. An SMES device according to any one of the preceding claims, characterised in that said inner layer (20) comprises a first plastics material having first electrically conductive particles dispersed therein, said outer layer (21) comprises a second plastics material having second electrically conductive particles dispersed therein and said intermediate layer (22) comprises a third plastics material.

19. An SMES device according to claim 18, characterised in that each of said first, second and third plastics materials comprises an ethylene butyl acrylate copolymer rubber, an ethylene-propylene-diene monomer rubber (EPDM) or an ethylene-propylene copolymer rubber (EPR), LDPE, HDPE, PP, PB, PMB XLPE, EPR or silicone rubber.

20. An SMES device according to claim 18 or 19, characterised in that said first, second and third plastics materials have at least substantially the same coefficients of thermal expansion.

21. An SMES device according to claim 18, 19 or 20 characterised in that said first, second and third plastics materials are the same material.

22. An electric power transmission system comprising an SMES device according to any one of the preceding claims connected to a high voltage source.

23. A high voltage system comprising an SMES device, characterised in that the SMES device has superconducting conductor means which is insulated against high voltage by an electric insulation system arranged concentrically around the conductor means.

24. A high voltage system according to claim 23, characterised in that the high voltage system comprises a high voltage network and that the SMES device is directly connected to the high voltage network without an intermediate transformer.

25. A high voltage system according to claim 24, characterised in that the network is a high voltage dc network.

26. A high voltage system according to claim 25, characterised in that the dc network is at a voltage exceeding 10 kV.

27. A high voltage system according to claim 24, characterised in that the SMES device is coupled to a high voltage ac network via a converter.

28. A high voltage system according to claim 25, comprising several ac networks connected via the dc network and the SMES device, the dc network being connected to the ac networks so that the SMES device can provide the ac networks with power.

29. A high voltage system according to any one of claims 23 to 28, characterised in that the SMES device comprises a coil.

30. A high voltage system according to any one of claims 23 to 28, characterised in that the SMES device comprises a cable without turns.

31. A high voltage system according to claim 27 of claim 29 when dependent on claim 27, characterised in that the SMES is one part of a bipolar dc link.

32. A high voltage system according to any one of claims 23 to 31, characterised in that said insulation system is extruded around the conductor means and comprises a first integral part forming an inner layer in electric contact with the conductor means and having semiconducting properties, a second integral part forming an outer layer around the insulation and having semiconducting properties and an insulating integral third part between the first and second integral parts.

33. A high voltage system according to an one of claims 23 to 31, characterised in that said insulation system comprises an all-synthetic film wound in overlapping

layers around the conductor means with an inner part in electric contact with the conductor means and having semiconducting properties, an electrically insulating intermediate part and an outer part surrounding the intermediate part and having semiconducting properties.

34. A high voltage system according to any of claims 23 to 31, characterised in that said insulation system comprising one or more of a cellulose-based, synthetic paper or non-woven fibre material, co-lapped or laminated with a synthetic film and having an inner part in electric contact with the conductor means and having semiconducting properties, an electrically insulating intermediate part and an outer part around said intermediate part and having semiconducting properties.

35. A high voltage system according to claim 32, 33 or 34, characterised in that a cooling medium for cooling said superconductive conductor is arranged to flow within the conductor means.

36. A high voltage system according to claim 32, 33 or 34 characterised in that a cooling medium for cooling said superconductive conductors is arranged outside of the conductor means.